

APPENDIX D

A Water Budget for Lake Istokpoga

INTRODUCTION

The purpose of this report is to provide a general water budget for Lake Istokpoga. The relative contributions of tributaries and rainfall were quantified and compared with water releases through the S-68 Structure and evapotranspiration losses. The amount of water released through the S-68 to the Indian Prairie Basin is compared with consumptive use permit allocations in the basin.

CALCULATION OF A LAKE ISTOKPOGA WATER BUDGET

The Hydrologic Equation

A simplified water budget for Lake Istokpoga was calculated with the following equation using existing data sets from the South Florida Water Management District's corporate environmental database DBHYDRO:

$$(\text{Inputs}) - (\text{Outputs}) = (\text{Change in Lake Volume})$$

Each equation element was derived from the following described sources.

Inputs

Inputs are calculated as: (Rainfall on Lake Surface + Inflow from Arbuckle Creek + Inflow from Josephine Creek). Some other sources have not been included in this analysis as they are either insignificant relative to the total input volume or there is insufficient measured data. Other sources include groundwater (which may be flowing into the lake at some times of the year and flowing out of the lake at other times) and miscellaneous surface water inflows such as local drainage ditches and recreational access canals.

Outputs

Outputs are calculated as: (Outflows through the S-68 Structure + Evapotranspiration). Some other sources have not been included in this analysis as they are either insignificant relative to the total input volume or there is insufficient measured data. Other sources include groundwater (which may be flowing into the lake at some times during the year and flowing out of the lake at other times) and outflow through the Istokpoga Canal.

Water flow through the Istokpoga Canal is generally negligible. A review of flow measurements at the G-85 Structure (in the Istokpoga Canal) from October 1983 through November 1988 indicate that no water flow was measured during this period. These results indicate that the volume of water flowing from Lake Istokpoga through the Istokpoga Canal is not a significant portion of the total water budget and has not been included.

Evapotranspiration (ET) is the combined loss of water vapor through direct evaporation of water from the lake surface and by transpiration of water vapor through the leaves of plants. Evapotranspiration is generally expressed as inches of water per year and, for application in this water budget, is translated into volume (ac-ft) of water per year for the average lake surface area. Evapotranspiration is generally regarded as one of the main hydrologic variables in south Florida, second only to rainfall (Irizarry-Ortiz *et al.* 2003). Several studies have been conducted to characterize evapotranspiration rates in south Florida, including Visher and Hughes 1969, Abtew 1996, Reardon and Abtew 2002, and Irizarry-Ortiz *et al.* 2003. An average annual value of 50 inches of ET was used in these calculations, following Visher and Hughes (1969).

Water Budget Calculations

The results from the water budget calculations for the period of record 1990-2000 are shown in **Tables D-1** through **D-4**. These results indicate that there is generally a surplus of water in the wet season and a deficit of water during the dry season. The amount of unaccounted water in the average annual budget over the period of record is small (1 % or less). Annual and seasonal variations in unaccounted water may reflect a carryover effect from a previous period that commonly occurs when imposing a calendar date cutoff to a variable data time series.

The volume of water unaccounted for in this water budget can range from relatively small (1,807 ac-ft) to significant (104,790 ac-ft) between water years. These variations may be the result of inter-annual differences in ET, groundwater influence or ungauged flows, or may be an artifact from the analytic method that imposes a calendar date cutoff to a variable data time series. Although there is variation from year to year, the decade average is approximately 1 percent or less of the water budget (7,139 ac-ft for water years, 78 ac-ft for calendar years). Walker and Havens (2003) estimate that ungauged inflows to Lake Istokpoga may be as much as 17 percent of the total gauged inflow.

Table D-1. Calendar-Year* Water Budget for Lake Istokpoga; all Values are Acre-Feet.

Year	Water Inputs to Lake			Water Outputs from Lake		Difference Between Inputs and Outputs	Change in Lake Volume for Year	Unaccounted Water Volume
	Rainfall	Arbuckle Creek	Josephine Creek	S-68	Estimated ET			
1990	91,275	146,347	34,894	197,266	118,405	-43,154	17,836	-25,318
1991	148,264	202,911	39,081	237,750	118,405	34,101	5,675	39,776
1992	138,689	170,733	36,150	58,895	118,405	168,273	-2,027	166,246
1993	115,412	111,488	33,738	140,232	118,405	2,001	-16,620	-14,619
1994	128,283	212,241	42,241	298,508	118,405	-34,148	-3,648	-37,796
1995	120,715	256,395	62,229	453,440	118,405	-132,505	6,486	-126,019
1996	83,649	120,835	26,557	148,291	118,405	-35,654	37,698	2,044
1997	143,735	224,230	29,905	262,657	118,405	16,808	-32,023	-15,216
1998	177,934	453,119	88,224	562,972	118,405	37,900	-5,675	32,225
1999	106,411	198,968	41,286	298,472	118,405	-70,212	-2,027	-72,238
2000	67,883	51,319	10,248	32,235	118,405	-21,190	72,965	51,775
Mean	120,205	195,326	40,414	244,611	118,405	-7,071	7,149	-78

*January 1 through December 31.

Table D-2. Water-Year* Water Budget for Lake Istokpoga; all Values are Acre-Feet.

Year	Water Inputs to Lake			Water Outputs from Lake		Difference Between Inputs and Outputs	Change in Lake Volume for Year	Unaccounted Water Volume
	Rainfall	Arbuckle Creek	Josephine Creek	S-68	Estimated ET			
1990	117,677	141,354	36,158	156,296	118,405	20,487	-22,295	-1,807
1991	144,193	191,130	36,208	215,392	118,405	37,734	12,972	50,706
1992	102,569	73,608	23,948	71,581	118,405	10,139	-1,621	8,518
1993	102,569	73,608	23,948	71,581	118,405	10,139	1,216	11,355
1994	126,449	255,554	44,277	371,030	118,405	-63,155	-4,864	-68,019
1995	114,265	235,028	63,851	401,150	118,405	-106,411	1,621	-104,790
1996	85,857	98,756	18,107	94,740	118,405	-10,425	31,618	21,193
1997	186,849	516,211	84,564	639,071	118,405	30,149	-36,482	-6,333
1998	120,687	165,458	37,047	229,094	118,405	-24,306	58,372	34,065
1999	109,793	199,274	40,742	277,808	118,405	-46,403	-30,402	-76,805
2000	68,198	35,838	6,865	32,746	118,405	-40,250	93,638	53,388
Mean	116,282	180,529	37,792	232,772	118,405	-16,573	9,434	-7,139

*May 1 through April 30.

Table D-3. Wet Season* Water Budget for Lake Istokpoga; all Values are Acre-Feet.

Year	Water Inputs to Lake			Water Outputs from Lake		Difference Between Inputs and Outputs	Change in Lake Volume for Year	Unaccounted Water Volume
	Rainfall	Arbuckle Creek	Josephine Creek	S-68	Estimated ET			
1990	77,056	107,347	27,037	121,481	70,332	19,626	-31,618	-11,992
1991	105,493	167,404	29,576	198,209	70,332	33,931	-10,539	23,392
1992	99,359	146,681	27,048	48,767	70,332	153,988	-18,241	135,746
1993	72,154	47,494	13,556	26,845	70,332	36,027	-32,023	4,003
1994	87,519	155,804	29,419	203,775	70,332	-1,365	-29,997	-31,361
1995	91,991	165,887	43,899	308,000	70,332	-76,555	-18,241	-94,796
1996	58,394	70,792	15,798	94,133	70,332	-19,482	18,241	-1,241
1997	96,521	91,081	18,253	115,243	70,332	20,280	-40,536	-20,256
1998	98,011	118,757	25,220	147,018	70,332	24,637	-4,054	20,584
1999	93,654	146,143	30,923	220,833	70,332	-20,446	-64,858	-85,304
2000	56,072	26,507	5,363	9,459	70,332	8,151	16,214	24,366
Mean	85,111	113,082	24,190	135,797	70,332	16,254	-19,605	-3,351

*May 1 through October 31.

Table D-4. Dry Season* Water Budget for Lake Istokpoga; all Values are Acre-Feet.

Year	Water Inputs to Lake			Water Outputs from Lake		Difference Between Inputs and Outputs	Change in Lake Volume for Year	Unaccounted Water Volume
	Rainfall	Arbuckle Creek	Josephine Creek	S-68	Estimated ET			
1990	40,621	34,007	9,121	34,815	48,309	625	9,323	9,948
1991	38,700	23,726	6,632	17,183	48,309	3,566	23,511	27,077
1992	45,408	67,531	21,046	109,172	48,309	-23,496	16,620	-6,876
1993	30,415	26,114	10,392	44,736	48,309	-26,124	32,429	6,305
1994	38,929	99,749	14,858	167,255	48,309	-62,027	25,132	-36,895
1995	22,274	69,140	19,951	93,150	48,309	-30,093	20,268	-9,825
1996	27,463	27,964	2,309	607	48,309	8,820	13,377	22,196
1997	90,329	425,130	66,311	523,828	48,309	9,632	4,054	13,686
1998	22,675	46,701	11,827	82,075	48,309	-49,181	60,804	11,623
1999	16,139	53,132	9,819	56,975	48,309	-26,194	32,429	6,235
2000	12,126	9,331	1,501	23,287	48,309	-48,638	77,018	28,381
Mean	35,007	80,230	15,797	104,826	48,309	-22,101	28,633	6,532

*November 1 through April 30.

Consumptive Use Withdrawals and Lake Istokpoga

All of the consumptive use permits in the Indian Prairie Basin are for agricultural uses (**Table D-5**), which include sod, sugar cane, citrus, pasture and livestock. A comparison of the actual amount of water use reported for users (**Table D-6**) with maximum annual allocations (**Table D-5**) indicates that less than one-third of the permitted water is typically used. A comparison of the maximum annual allocation for all permits (**Table D-5**) with the volume of water discharged to Indian Prairie through the S-68 (**Table D-1**) indicates that there is typically enough water in most years to meet maximum demands. However, in below-average rainfall years (e.g., calendar years 1992 and 2000), there may not be enough water discharged from the S-68 to meet maximum demands. The current regulation schedule prevents water from being discharged from Lake Istokpoga for water supply use when water levels fall below Zone B (**Figure D-1**).

Table D-5. Consumptive Use Permits in the Indian Prairie Basin; All Units are Acre-Feet.

Permit Number	Max Monthly Allocation	Max Annual Allocation	Permit Type
22-00003-W	954	5,084	AG-sugar cane
22-00019-W	8,165	49,625	AG-pasture
22-00021-W	2,102	12,661	AG-no longer in use
22-00032-W	567	3,288	AG-pasture
22-00046-W	312	1,808	AG-pasture
22-00049-W	1,566	5,665	AG-pasture
22-00052-W	1,377	6,937	AG-citrus/pasture/livestock
22-00056-W	616	3,717	AG-sugar cane/pasture/citrus
22-00064-W	443	2,202	AG-citrus
22-00117-W	334	1,707	AG-citrus
22-00140-W	57	155	AG-citrus
28-00023-W	2,082	3,684	AG-pasture
28-00081-W	560	3,041	AG-pasture
28-00120-W	834	5,331	AG-sod
28-00123-W	908	5,140	AG-citrus
28-00129-W	1,180	5,988	AG-sod
28-00133-W	454	2,694	AG-citrus
28-00256-W	700	3,801	AG-pasture
28-00440-W	597	4,299	AG-citrus/sod
Total	23,807	126,380	

Table D-6. Summary of Annual Pumpages Reported for Indian Prairie Users (1998-2003); Units are Water Volume Expressed as Acre-Feet.

Permit	Annual Permitted	Average Actual Pumpage	Percent Used
19-W	49,625	15,021	30
332-W	3,288	682	21
49-W	5,670	1,765	31
117-W	1,707	278	16
23-W	3,684	980	27
120-W	5,331	273	5
129-W	5,988	1,140	19

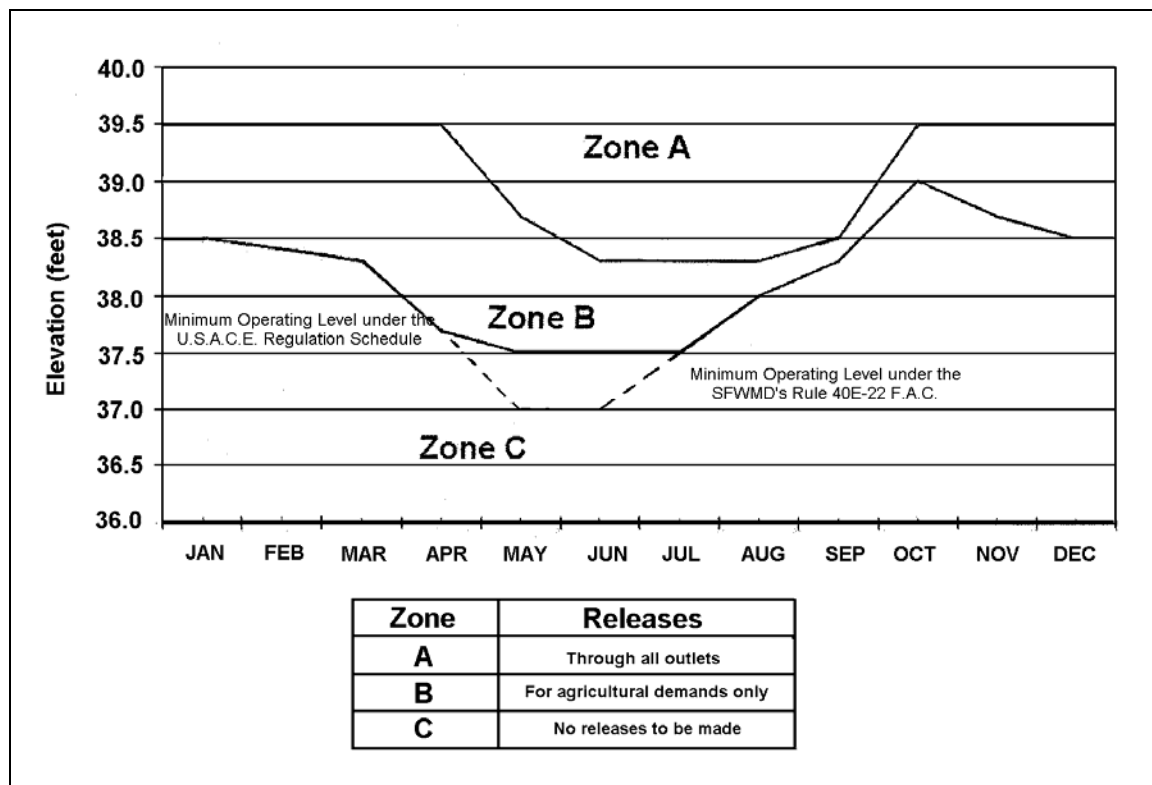


Figure D-1. Regulation Schedule for Lake Istokpoga.

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